716. f. 5.
3

THE
Deſcription *and* Uſe
Of a NEW
Sea Quadrant,

FOR
Taking the ALTITUDE of the SUN
from the viſible HORIZON;
Which is ſo contrived,
That the Obſerver will be liable to no Interruption, or Inaccuracy from the Ship's Motion.

AND
The LATITUDE at SEA,
May be obtained with greater Certainty, and more
frequently than by any Inſtrument of the like
Kind hitherto made publick.

Invented, Made, and Sold by
GEORGE ADAMS,
Mathematical Inſtrument Maker to His MAJESTY's
Office of ORDNANCE, at *Tycho Brahe's Head*, the
Corner of *Racquet Court*, in *Fleetſtreet*, *London*.

To which is added,
The DESCRIPTION and USE of two Curious METHODS
for procuring an
ARTIFICIAL HORIZON at SEA,
To be uſed with *Hadley*'s Quadrant; one by Means of a
Whirling Speculum; the other by a Floating Mirrour.

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INTRODUCTION
TO THE
New Sea Quadrant.

THE QUADRANTS now in Uſe at SEA, are either too *Imperfect* in their Kind to take an accurate and eaſy Obſervation, or too expenſive in their Conſtruction to grow into more general Uſe among the Bulk of Mariners.

The firſt of theſe has ſtood the Teſt of many Ages, and is ſtill in good Repute, notwithſtanding the many Inconveniences and Difficulties that attend the Uſes of it.

By the laſt is meant the *Reflecting Quadrants*, which certainly are the moſt extenſive of any, for anſwering all the Purpoſes of ſuch Inſtruments, and ſeem to require no conſiderable Improvement.

In order therefore to remove the *Imperfections* of the former, and Expence of the latter, I have *conſtructed* a QUADRANT, which is *freed* from all the *Incorrectneſs* complained off againſt *Davis*'s; and alſo have *added* to it, *one of the moſt uſeful Properties*, for which the Reflecting Quadrants have been ſo much eſteemed.

But before I proceed to give a Deſcription of it, it will be requiſite to lay before the Reader ſome of the principal Objections to which *Davis*'s Quadrants are liable; whereby he will be the better enabled to judge of the Advantage gained in this of mine.

Inconveniencies in the Uſe of Davis's *Quadrant conſidered.*

The principal Difficulty attending the Uſe of *Davis*'s Quadrant, ariſes from its Conſtruction, whereby the Motion of the Ship continually interrupts and diſturbs the Obſervation, by altering the due Poſition of the Inſtrument, and thereby ſnatching the Horizon, as well as the Shadow, or Sun's Image, out of Sight on a ſudden; ſuffering them, as it were, to return only by Fits, and ſmall Intervals; and the vibratory Motion of the Sun's Image, makes it difficult to be diſcerned; inſomuch, that an Obſervation taken in hazy Weather, which ſeems to be tolerably correct, will, from this Circumſtance alone, be frequently found twenty Minutes or more, different from one made immediately after; if by chance the Sun appears bright, and the Weather clears up.

Likewiſe the Trouble that attends the adjuſting of the Vanes is very great and uncertain; for in order to place the Shade or Glaſs Vane on a proper Degree, that it may be no more removed during the whole Time of Obſervation; ſome Judgment muſt be formed of the Sun's Meridian Altitude; then the Sight Vane muſt be moved up or down the thirty Arch, until the Rays from the Horizon, and Shade, or Spot of Light from the Sun, exactly coincide on the fiducial Edge of the Horizon Vane; and this may be frequently done in moderate Weather, on calm Seas, with a clear Sky, when the Sun is not too high. Yet it requires more Accuracy than can poſſibly be applied, and more Time than can generally be allowed for it.

Alſo when the Sun's Altitude is about 45 Degrees, he riſes and falls very ſlowly; inſomuch that he takes up about 5 Minutes, 34 Seconds of Time in riſing and falling one Minute of an Arch in Altitude. Whereas, if he ſhould paſs over the Zenith, he riſes or falls one whole Degree in four Minutes of Time. Therefore in one Minute of Time he riſes or falls, at leaſt, fifteen Minutes in Altitude. The Difference of which, is more than eighty to one.——For this Reaſon *Davis*'s Quadrant cannot be depended on, in taking the Latitude of thoſe Places, where the Sun paſſes either in or near the Zenith.

Mr. *Joſeph Harris*, in his excellent Treatiſe of Navigation, page 177. makes the following Remark on the bad Conſtruction of *Davis*'s Quadrant, which take in his own Words. “ The Slit of the Horizon Vane is “ always cut ſloping, ſo that the upper Edge “ of the Slit on the fore Side of the Vane, “ and the lower Edge of the Backſide, are “ directly in a right Line, paſſing thro' the “ Center near the Middle of the Quadrant; “ ſo that when the Sight Vane happens to be “ at 25, or 30 Degrees, the Opening in the “ Horizon Vane appears ſo contracted, that “ you cannot ſee the Horizon ſo diſtinct as “ you ought to do; and the ſaid Opening “ will appear Wider or Narrower, according “ as the Sight Vane is nearer to, or farther “ from the Beginning of Degrees; this Me- “ thod, ſays he, of ſlitting the Horizon Vane, “ is evidently very inconvenient and abſurd, “ for the Reaſons above given; and in page “ 178, he wonders what could be the Mean- “ ing of this imaginary Conveniency, of hav- “ ing two Centers to the ſame Inſtrument, “ that ſo the Obſerver might make uſe of “ either of the Edges, or obſerve any where “ between them; at leaſt, I know, ſays he, “ that that is the common Notion of Mari- “ ners; and this leads them into Error more

" or leſs, according as they obſerve more or
" leſs open, (as they call it) or the Poſition of
" the Sight Vane, is nearer to, or farther from
" the Beginning of Degrees."

If the moſt ſkillful Perſon about Noon Day, when the Sun is low in the Meridian, and does not perceptibly riſe or fall for ſome Minutes of Time, as ſoon as he has noted the Altitude found by *Davis*'s Quadrant, was to pull off, or remove the Vanes, and immediately repeat the Obſervation anew; he will very ſeldom, unleſs by Chance, come within five or ſix Minutes of his former, as has been often proved by Trials.

Upon theſe, as well as other Conſiderations, it requires much Time and Practice, as well as Judgment and Dexterity in the Obſerver, to enable him to manage *Davis*'s Quadrant at Sea.

Whereas, the Uſe of this New Quadrant, may be learned, with great Eaſe, in a Quarter of an Hour, by a Perſon unaccuſtomed to make Obſervations, and the Motion of the Ship will give him no Interruption or Diſturbance; for when the Sun's Image, by ſliding the Index, is once brought to appear upon the ſame Line with the Horizon, or Edge of the Sea, the two Objects will continue to be ſeen in the ſame Situation, without ſeparating; howſoever they may appear to be moved upwards or downwards, by the Rowling of the Ship, or Unſteadineſs of the Obſerver's Hand.

Reflecting on the above-mentioned Inconveniencies, I recollected, that Mr. *Thomas Godfrey* of *Philadelphia*, in the Years 1728, and 1729, had carefully conſidered the Diſadvantages that attended *Davis*'s Quadrant, and with the utmoſt Diligence applied himſelf to find out ſome Contrivance for the Removal of them; at laſt, converted *Davis*'s Quadrant, into what he calls the Mariner's Bow; and of this Improvement he was fully ſatisfied, by the Accounts of ſome Maſters of Veſſels, who uſed them in their Voyages from *Philadelphia*, to different Parts of the *Weſt Indies*, in the Year 1730, as may be ſeen in the *Philoſophical Tranſactions*, N° 435, in a Letter from Mr. *Logan* of *Philadelphia*, to Dr. *Halley*, in the Year 1732.

But tho' Mr. *Godfrey* has in the Conſtruction of his Bow, provided againſt ſome of the Imperfections of *Davis*'s Quadrant, and Mr. *Logan* informs us that it may be adjuſted, and an Obſervation taken by it in one fourth Part of the Time that *Davis*'s Quadrant requires; yet it is ſtill liable to other very great Inconveniencies.

For the Arch conſiſts of 100 Degrees, and is two Feet, or twenty Inches at leaſt Radius, by which Means it becomes too bulky, and conſequently very troubleſome to manage, in high and tempeſtuous Seas; and likewiſe, as the Center of the Slit in the ſmall circular Arch, which is uſed for the Horizon Vane, muſt always be perpendicular to forty five Degrees, and from the Nature of the Conſtruction of the Inſtrument, the two other Vanes, which move upon the great Arch, and conſtitute the Sight and Shade Vane, muſt alſo be equally diſtant from 45 Degrees; and therefore, when the Sun's Altitude increaſes or decreaſes, both theſe Vanes muſt be equally altered, or that Difference of the Sun's Altitude muſt be equally divided between them, in order to keep the one as much below 45 Degrees, as the other is above it; to do which, the Inſtrument muſt be taken from the Eye, and many Trials made, before it can be readjuſted.

There is ſtill one Imperfection more in his Bow, which appears to be unavoidable from its Conſtruction; and that is, both the Radius and the Arch being ſo great, that the Arch will be very apt to twiſt, and render all the Obſervations that are taken by it falſe.

However, as the Bow hath this peculiar Advantage in the Horizon Vane, being of a ſmall circular Arch, and the Opening of the Slit therein an Inch on each Side the Center of the Quadrant: —— The Latitude may be taken with Eaſe, within 14 Seconds; nay, even to 4 Seconds, and with a little more Care without any Error at all.

I immediately ſaw that all theſe Imperfections in Mr. *Godfrey*'s Inſtrument, might be provided againſt, by placing that ſmall circular Arch in the Center of a Quadrant, whoſe Radius is about 10 Inches, which will be leſs liable to ſpring or twiſt than either *Davis*'s Quadrant, or the Bow, and far leſs troubleſome than the latter in tempeſtuous Weather; which gave Birth to the New Quadrant under Conſideration, the Deſcription and Uſe of which I now proceed to explain.

THE

THE

Deſcription *and* Uſe

Of a NEW

Sea Quadrant:

Invented, Made, and Sold by

GEORGE ADAMS,

At *Tycho Brahe's Head*, the Corner of *Racquet Court*, in *Fleetſtreet*, *London.*

THIS Quadrant is about 10 Inches Radius, and hath one of its Sides produced to 18 Inches, as in Figure 1, where ABC is the Quadrant, C its Center, having the Side CA produced to D. At the Center C is fixed the circular Horizon Vane EF, whoſe Radius is to that of the Side CD, as 6. 4. to 10. This

Vane moves round on the Center C. Upon the Extremity D of the Side C D, is fixed a Braſs Vane K, perpendicular to the Plane of the Quadrant, in the Center of which is a Convex Lens, as O, whoſe focal Diſtance is particularly adapted to the Curvature of the Horizon Vane; ſo that the Image of the Sun formed by it, will fall upon the Horizon Vane E F, between h and m. On the back Side of the Quadrant is placed the Index L M, which is alſo moveable about the Center C, and is of the ſame Length and Breadth with the produced Side C D. On the Extremity of this Index, is fixed a Braſs ſight Vane N, perpendicular to the Plane of the Inſtrument, in which is made a ſmall Perforation I, at ſuch a Diſtance from the Plane of the Quadrant, that when the Index is brought into Contact with the produced Side C D, the Center of the Perforation I, lies in the ſame Line with the Center of the Convex Lens O, and in this Situation a right Line paſſing thro' the Points I, O and C, exactly paſſes over o, or 90 Degrees on the Quadrant.

Upon this Index C M, there is a ſmall circular Arch Q R, concentric with the quadrantal Arch, and moves exactly upon the Plane thereof; this Arch Q R contains the *Nonius* Diviſions for ſubdividing the Degrees of the Quadrant into ſingle Minutes, which ſhall be afterwards fully explained. On the underſide of this *Nonius*, and on the Back-ſide of the Quadrant, there is a Screw for fixing the Index at any Degree or Minute.

The Arch contains ſix or eight Degrees more than the Quadrant, having either 3 or 4 Deg. on each Side thereof at A and B. on Account of the *Nonius* Diviſion.

The Limb A B of the Quadrant is numbred both Ways, beginning from the Point A, at 0 Deg. and then marked 10. 20. 30. 40. *&c.* to 90 Degrees towards B; and on the inner Side, it again begins from 0 Deg. at B, and then is marked 10. 20. 30. 40. *&c.* to 90 Degree towards A; each Degree is ſubdivided into three equal Parts, which conſequently are twenty Minutes each. The whole Degrees are diſtinguiſhed by Lines drawn through three concentric Circles, and the other Subdiviſions of 20 Minutes each, are pointed out by Lines drawn thro' the two outward concentric Circles.

But as theſe laſt Diviſions conſiſting of twenty Minutes each, are again ſubdivided into ſingle Minutes, by Means of the *Nonius* Diviſion: We judge it altogether neceſſary to explain the *Nonius* Diviſion in general, before it is applied in particular to the Diviſions of this Inſtrument.

A general Explanation of Nonius's *Diviſion.*

Peter Nonius, before the End of the ſixth Century, invented the following Method for ſubdividing a Line into the 10th, 20th, or 30th, &c. Part of its primary Diviſion. Thus

Suppoſe a Line as A B, Fig. 2, 3. or 4. divided into any Number of equal Parts, as A C, C D, D B, &c. which we ſhall here ſuppoſe to be Inches, and let each of theſe Inches be ſubdivided into ten equal Parts; then let any other Line, as F G be applied to the Line A B, ſo as to ſlide along the ſaid Line A B, and always keep in cloſe Contact with it.

Then if it be required to ſubdivide the tenths of Inches into any other Number of equal Parts. F G, muſt be equal to as many of thoſe tenths, except one, as is denominated by the Number of Parts, into which theſe Tenths are required to be ſubdivided. That is,

If it be required to ſubdivide the tenths of Inches into

10	Equal parts	FG muſt be ſet off equal to	9	of thoſe tenths	and then divided into	10	Equal parts	as
20			19			20		
30			29			30		

plainly appears in the figures 2, 3 and 4,— and the ſame is to be done with any other Number whatſoever.

We ſhall call the middle Diviſion M of the Line F G, the fiducial Line; becauſe from this Line the Subdiviſions of the Tenths of the Inches are reckoned.

Now, ſince F G is equal to as many Parts of the Line A B, except one, as is denominated from the Number of Parts, into which thoſe in the Line A B are required to be ſubdivided, and the Line F G itſelf, is alſo divided into as many equal Parts, as thoſe in the Line A B are required to be ſubdivided into. It plainly appears that each of theſe equal Parts in the Line F G, will be defective of thoſe in the Line A B, by the part denominated, from that Number into which thoſe in the Line A B are required to be ſubdivided. That is

If the Tenths of the Inches is required to be ſubdivided into twenty equal Parts, as in Fig. 3. then each of the equal Parts in the Line F G will be defective of the Tenths, by one twentieth Part of one of theſe Tenths.

Becauſe in this Caſe F G being equal to nineteen Tenths, and is divided into twenty equal Parts, each Diviſion in F G, will be one twentieth of nineteen Tenths, that is, nineteen twentieth's of one Tenth, and conſequently each Diviſion in F G, is ſmaller than a Tenth, by one twentieth Part of one Tenth.

For the ſame Reaſon, if it is required to ſubdivide each Tenth into thirty equal Parts, then will each Diviſion in F G be ſmaller than one Tenth, by one thirtieth Part of a Tenth, as in Fig. 4.

If theſe Tenths are only required to be ſubdivided into Tenths, as in Fig. 2. in this Caſe each Diviſion in F G, will be ſmaller than the Tenths of Inches, by one Tenth Part of a Tenth, that is, by one hundredth Part of an Inch, and the ſame may be underſtood of any other Number into which the Tenths of the Inches A C, C D, D B, *&c.* is required to be ſubdivided.

Suppoſe for Example, they are ſubdivided into other Tenths, which is Hundred Parts of the whole Inch; and it is required, by the Aſſiſtance of the Line F G, to take off one Inch 4 Tenths, and one hundredth Part. — Place the fiducial Line M, a little nearer the ſecond Inches D, than one Inch and four Tenths, in ſuch a Manner, that the firſt Diviſion in the Line F G, between M and G, may exactly correſpond with one Inch and five Tenths.

Then becauſe the firſt Diviſion in the Line F G, from the fiducial Line M, on the right Hand of it, coincides with the firſt Diviſion of the Inches beyond one Inch and four Tenths, and each Diviſion in the Line F G, being ſmaller than one Tenth of an Inch by one hundredth Part of an Inch; it is manifeſt, that the fiducial Line M, will be to the right Hand of one Inch four Tenths, by one hundredth Part of an Inch.

Therefore, the fiducial Line in that Poſition will point out one Inch four Tenths, and one hundredth Part of an Inch.

For the ſame Reaſon, if the ſecond, third, fourth or fifth Diviſion in the Line F G, between the fiducial Line M, and the Point G, correſpond with the ſecond, third, fourth, or fifth Diviſion on the Tenths, from one Inch four Tenths on the right Hand thereof; then will the fiducial Line M, point out one Inch four Tenths, and two three, four, or five hundredth Parts reſpectively.

Again, if the firſt, ſecond, or third Diviſion, &c. in the Line F G, between the fiducial Line and point F, exactly correſpond with the firſt, ſecond or third Tenth, &c. between one Inch five Tenths, and one Inch, or to the left Hand of one Inch five Tenths; as ſuppoſe the firſt Diviſion from the fiducial Line correſpond with one Inch four Tenths, then will the fiducial Line M, be defective of one Inch five Tenths, by one hundredth Part of an Inch, and will therefore be more than one Inch four Tenths, by nine hundred Parts of an Inch; that is, the fiducial Line M in this Caſe, will point out one Inch four Tenths, and nine hundred Parts of an Inch.

For the ſame Reaſon, if the fourth Diviſion on the Line F G, upon the left Hand of the fiducial Line M, correſpond with one Inch one Tenth, then will the fiducial Line be defective of one Inch and five Tenths, by four hundred Parts of an Inch; that is, the fiducial Line will point out one Inch four Tenths, and ſix hundred Parts of an Inch; from hence it is plain, that every Diviſion in the Line F G to the right Hand of the fiducial Line M, correſpond to one hundred Parts, and the Diviſions at G and F, will each correſpond to five hundred Parts; but the Diviſion on the left Hand of the fiducial Line M, are reckoned from F to M, beginning at five hundred Parts, and ending at nine hundred Parts; and if the fiducial Line itſelf correſpond with any of the Tenths, in that Caſe there is no fractional Part at all, below that particular tenth Part; and hence by the Line F G, fig. 2. the tenth Parts of an Inch are ſubdivided into hundred Parts, and in the ſame Manner is any other Subdiviſion reckoned.

This is what has always been called the *Nonius* Diviſion to any Graduation whatſoever, from the Name of its Inventor. However abſurd it may be called *Vernier*, for no other Reaſon, than that one *Peter Vernier* explained that Diviſion about 30 Years after *Peter Nonius* died.

The Deſcription of the Nonius *Diviſion, as applied to the Arch of the New Quadrant.*

As every Degree on the Quadrant is ſubdivided into three equal Parts, or twenty Minutes; therefore to ſubdivide thoſe Diviſions into ſingle Minutes, it is neceſſary, that nineteen of theſe Diviſions, or ſix Degrees and twenty Minutes be taken for the Length of the *Nonius*, as S T fig. 1. and fig. 5. (in fig. 5. I have ſubſtituted a Part of the quadrantal Arch, and ſo much of the Index as contains the *Nonius* Diviſion of a larger Size, that the Reader might more readily underſtand the Nature of it, than could be done where the Diviſions are ſo ſmall, as they are in figure 1.) and that Line S T, divided into twenty equal Parts, then will each Diviſion in the Line S T be ſmaller than the third Part of a Degree, or twenty Minutes, by the twentieth Part of twenty Minutes, that is, by one Minute.

Let the fiducial Line V in fig. 5. of this *Nonius*, lye between 25 and 26 Degrees, reckoning from A towards B, and paſt the ſecond Diviſion or 40 Minutes, ſo that the ſixth Diviſion from the fiducial Line V of the *Nonius* between V, and S, exactly correſpond with the ſixth Subdiviſion of the Degrees from 24 Deg. 40 Min. then will the fiducial Line correſpond to 6 Min. more than 25 Degrees 40 Minutes; that is the Angle A C V, fig. 1. made by the Index and Leg of the Quadrant C D, will be an Angle of 25 Deg. 46 Min.

If the Angle be reckoned upwards from B, towards A, it will be more than 64 Degrees, but will want 6 Minutes of 64 Degrees 20 Minutes; that is, the Angle B C V, fig. 1. will be an Angle of 65 Degrees 14 Minutes, as in fig. 5.

Again, if reckoning from A to B, the fiducial Line ſhould ſtand between 36 and 37 Degrees, but not reach to 20 Minutes, and the ſecond Diviſion of the *Nonius* from V to T, ſhould exactly correſpond to the ſecond Diviſion on the Quadrant in the ſame Direction, then will the fiducial Line be only defective of 36 Degrees, 20 Minutes, by two Minutes, that is, the Angle A C V, would be 36 Degrees, 18 Minutes.

But if the Angle be reckoned from B to A, the fiducial Line will point out 2 Min. more than 53 Deg. 40 Min. that is, the Angle B C V would be 53. 42 Minutes.

Hence it follows, that the Diviſions of the *Nonius* muſt be always reckoned the ſame Way with thoſe of the Degrees on the Quadrant; that is, if the Degrees are numbered from the Right Hand towards the Left, you muſt always remember to count the Diviſions of the *Nonius* from the Right towards the Left alſo.

And if the Degrees are numbered from the Left Hand towards the Right: Alſo count the Diviſions of the *Nonius* from Left to Right, *viz.*

If the Degrees are numbered from A to B, fig. 5. the Diviſions on the *Nonius*, begin their Count at the fiducial Line V, and go on towards the left Hand, 1, 2, 3, &c. to 10.

at S. Then beginning again by 10, at T, proceed on ſtill toward the left Hand, 11, 12, 13, &c. to 20 Minutes, which is the fiducial Line V.

But on the contrary, when the Deg. are numbered from B to A: The Diviſions begin as before, from the fiducial Line V, and go on towards the Right Hand, 1, 2, 3, &c. to 10 at T, where the Diviſion ends; then beginning again at 10 from S, proceed ſtill towards the Right Hand, 11, 12, 13, &c. to 20 Minutes at V, which brings you to the fiducial Line again.

Having now fully laid down the Nature, Conſtruction, and Uſe of that admirable Invention of *Peter Nonius*, which I hope will be evident to thoſe who have not hitherto had the Opportunity of having it explained to them before, and for whom this is chiefly intended, I now proceed to explain,

The Use of the New Sea QUADRANT,

Invented, Made, and Sold by

GEORGE ADAMS,

At *Tycho Brahe*'s *Head*, in *Fleetſtreet*, *London*.

TAKE the Quadrant in your Left Hand, and hold it perpendicular to the Horizon, with your Back towards the Sun, as in fig. 1. then with your Right Hand, move the Index CM up or down, applying your Eye to the Perforation I of the Sight Vane N, till ſuch Time as the Image of the Sun, formed by the Convex Lens O of the glaſs Vane K, be caſt upon the middle Line HG of the Horizon Vane EF, at the ſame Time that the Horizon is ſeen correſponding to the ſame fiducial Line HG, on both Sides thereof: Always remembering to turn the circular Vane EF, ſo as the Center of it may be nearly perpendicular to the Middle between the point A, and the fiducial Line of the *Nonius* Diviſion V. Then is the Quadrant adjuſted to the Obſervation, and the Angle ACV, reckoned by the *Nonius* Diviſion as above explained, gives the Altitude of the Sun above the Horizon, and the Angle BCV, his Zenith Diſtance, or the Complement of his Altitude.

The adjuſting of the central Line on the Horizon Vane, to the Middle, between A and V, requires no great Degree of Accuracy; becauſe when the Image of the Sun and the Horizon is at either of the Extremities of the Slit E F, there is but an Error of 57 Seconds, and conſequently, if they be near the middle Line H G, it is perfectly exact, without ſo much as an Error of one Second.

It is neceſſary to obſerve, that from this Contrivance, when the Image of the Sun is caſt on the Bar E F of the Horizon Vane, any where between h and m, and the Horizon ſeen on each Side thereof to be in the ſame Line with it, they will both move together, ſo that no poſſible Error can enſue from taking the Altitude of the Sun at Sea, by this Quadrant, from the Pitching and Rowling of the Ship.

This is a great and principal Advantage in this Quadrant, which no other Quadrant has, except the reflecting Ones. It hath alſo another valuable Property, that it may be adjuſted to the Sun's Altitude in leſs than half a Minute, and readjuſted to the different Altitudes of the Sun, as he approaches the Meridian in a few Seconds.

That the Latitude of a Place taken by this Inſtrument, may be as correct as poſſible; it muſt be obſerved, that when the Eye of the

Obſerver, is above the Surface of the Sea, the Plane paſſing thro' the Center of his Eye, parallel to the Horizon, will be above the real Horizon, and conſequently, the Horizon ſeen through the Slit of the Horizon Vane will be below the real Horizon; ſo that the Altitude of the Sun taken by the Quadrant, will by that Means be as much greater than his real Altitude, as the Plane of that apparent Horizon is below that of the real one; and therefore, that Difference being eſtimated, muſt be taken from his obſerved Altitude, in order to find his real Altitude; and as the Height of the Obſerver's Eye, is more or leſs from the Surface of the Sea, I have inſerted a Table of Correction for that Purpoſe.

Since from the Principles of Optics, Rays of Light in paſſing from a Rarer into a Denſer Medium, are refracted towards the perpendicular; therefore the Rays that proceed from the Sun, muſt, by the interpoſing Atmoſphere, be refracted towards the Perpendicular, before they can reach the Surface of the Earth; conſequently, the obſerved Altitude will be greater, than the Sun's real Altitude.

The Refraction being different in different Altitudes, I have inſerted Mr. *Flamſtead*'s Table thereof.

And as both theſe Errors are to be ſubſtracted from his apparent Altitude on the Quadrant; Therefore if the Minutes correſponding to the Height of the Eye, above the

Surface of the Sea, be added to the Minutes and Seconds in the Table of Refractions, anſwering to his apparent Altitude; and their Sum ſubſtracted from the Altitude given by the Quadrant, the Remainder will be the Sun's true Altitude.

N. B. If the Zenith Diſtance be taken, both theſe Errors are to be added thereto.

To find the Latitude at Sea, an Obſervation muſt be made, and frequently repeated, before the Sun comes to the Meridian, in order to obtain his greateſt Height, or Meridian Altitude; by which, and the Declination of the Sun, taken out of the Tables for that Purpoſe, the LATITUDE may be readily found, according to the common Rules delivered in every Treatiſe of Navigation.

A TABLE, *ſhewing the Depreſſion, or Dip, of the viſible Horizon, below the true Horizontal Plane*; according to the ſeveral Heights (therein mention'd) of the Obſerver's Eye above the Surface of the Sea; to be *ſubſtracted* from the Altitude found by the Inſtrument, and added to the Zenith-Diſtance.

The Eye above the Surface of the Sea, *in Feet.*	Viſible Horizon depreſs'd *in Minutes.*
1	1
3	2
7	3
12	4
18	5
27	6
40	7

Mr. FLAMSTEAD'S *TABLE of Refraction, to be ſubſtracted from the* Altitude, *and added to the* Zenith-Diſtance, *found by the Inſtrument.*

Deg. Appt. Alt.	Refract.		Deg. Appt. Alt.	Refract.		Deg. Appt. Alt.	Refract.	
°	′	″	°	′	″	°	′	″
0	33	00	18	2	29	41	0	56
½	26	38	19	2	21	42	0	54
1	23	22	20	2	14	43	0	52
1½	20	17	21	2	07	44	0	50
2	17	26	22	2	01	45	0	48
2½	15	15	23	1	55	46	0	46
3	13	23	24	1	50	47	0	45
3½	11	53	25	1	45	48	0	44
4	10	39	26	1	40	49	0	42
4½	9	38	27	1	36	50	0	40
5	8	48	28	1	31	51	0	39
6	7	26	29	1	27	52	0	38
7	6	25	30	1	23	53	0	37
8	5	37	31	1	20	54	0	36
9	5	02	32	1	17	55	0	34
10	4	33	33	1	14	60	0	29
11	4	06	34	1	11	65	0	24
12	3	45	35	1	09	70	0	19
13	3	29	36	1	07	75	0	14
14	3	13	37	1	05	80	0	09
15	3	00	38	1	02	85	0	04
16	2	48	39	1	00	90	0	00
17	2	38	40	0	58			

An Eſſay to make this Inſtrument ſerviceable at Sea, when there is no Horizon to be ſeen.

In order to adapt it for ſo beneficial a Purpoſe, an Air level may be fixed on the Index CM, whoſe upper Surface muſt be ſet parallel to the upper Edge of the Index; and then the Sun's Altitude, may be taken in hazy Weather, to a tolerable Degree of Exactneſs, *viz.*

Let any Perſon on board, who has a ſteady Hand, hold the Quadrant before him, and keep the Spot of Light or Sun's Image, conſtantly on the middle Line H, of the Horizon Vane; at the ſame Time let him ſlide the Index up or down the Arch, till the Air bubble plays in the Middle of the two Threads, which are on the Top of the Spirit Tube —— and when this happens at the ſame Time the Sun's Image is on the aforeſaid Line, the *Nonius* Diviſion will point out the Sun's Altitude.

In ſtill Weather, when the Ship has no great Motion, an Obſervation may be made this Way without much Difficulty.—— And

We can alſo aſſure the Curious, amongſt the Sea faring Gentlemen, that the Latitudes of the Ports may be taken on Shore by this Method to a very great Degree of Exactneſs.

THE Deſcription *and* Uſe OF TWO CURIOUS METHODS For procuring an Artificial HORIZON at SEA.

Made and Sold by

GEORGE ADAMS,

Inſtrument-Maker to his MAJESTY's Office of Ordnance, at *Tycho Brahe*'s *Head*, in *Fleet-ſtreet*, *London*.

The firſt by Means of a Whirling Speculum, Invented by Mr. *JOHN SEARSON*.

The Second by Means of a tranſparent Plain, floating upon the Surface of Mercury, Invented by Capt. *HENRY ELLIS*.

BY the Help of Mr. *Hadley*'s Quadrant, and either of theſe Inſtruments, the Altitude of the Sun or Stars, may be obtained to a great

Degree of Exactneſs, when the Horizon cannot be ſeen.

It very often happens even in moderate and calm Weather, to be ſo hazy, that the Horizon is over-caſt, and not to be ſeen at Sea, for ſeveral Days together; at ſuch Times the Latitude may be aſcertained by the Whirling Speculum, or floating Mirrour.

Within three or four Minutes, in almoſt all Weathers, and in ſtill Weather, when the Ship has no great Motion, within one Minute of the Truth. A Thing extremely uſeful, particularly to ſuch Ships as are endeavouring to make the *Engliſh* Channel after a long Voyage.

Beſides, if the Sun ſhould not appear at Noon, which too frequently happens, ſo that his Meridian Altitude cannot be obtained; yet the Heavens may be clear and ſerene at ſome Time or other of the Night: And ſince at all Hours there will be ſome or other of the Stars on or near the Meridian, the Opportunities of taking their Altitudes, (by the Help of the Floating Mirrour, or Whirling Speculum) and conſequently of finding the Latitude at Sea, will be almoſt as frequent as can be deſired, an Article of great Uſe and Importance in Navigation.

The

The Deſcription of the Whirling Speculum.

The Speculum is a circular Plane, ſo well poliſhed, as to reflect the Image of the Sun, or Stars of the 1ſt and ſecond Magnitude very diſtinctly; it has an Axis paſſing thro' its Center at Right Angles to the reflecting Plane; on the lower Point of which, by a vigorous circular Velocity, from the known Laws of Motion, Gravity, *&c.* it perſeveres, (notwithſtanding the Ship's Motion) in a paralleliſm with the Horizon; or in other Terms, perpendicular to the Direction of Gravity, a Space of Time nearly proportionable to the communicated Velocity; hence its Uſe for taking Altitudes at Sea.

The Apparatus belonging to it are a ſquare Mahogany Box, with an angular Cover or Roof; in which are fitted two tranſparent Glaſſes, through which the Sun's Image is received upon the Speculum, and thence reflected to the Eye of the Obſerver; and when in Uſe, is to keep the Wind from diſordering the Speculum.

There is alſo a particular Machine, contrived on Purpoſe to give it Motion, by Means of a Piece of Tape, which is ſo ordered, as to diſcharge itſelf from the Speculum, the Inſtant it has done its Office, which I ſhall call a Whirler.

To whirl the Speculum.

Lay it in the ſquare Mahogany Box, with its Axis upon the Pedeſtal in the Center thereof; then place the Holes in the Ends of the Whirler over the Pins for that Purpoſe, which are in the higheſt Sides of the Box, and put the ſquare Hole at the End of the whirling Axis, over the upper End of the Axis of the Speculum, the Tape being firſt wound hard thereon

This being done with your left Hand, keep the Whirler faſt, and with the Right Hand, putting your Finger into the Loop of the Tape, by a gradual increaſing Force draw off the Tape, at which Inſtant the Cylinder will be lifted up from the Axis of the Speculum. Take away the Whirler, and if you find it needful, put on the Roof, and the Speculum is ready for Obſervation: In drawing off the Tape, take particular Notice not to pull with a ſudden Jerk at firſt. — Let the Perſon who holds the Box, ſtand or ſit, if need require, as ſtill as may be, and obſerve, that the Speculum play freely upon its concave Pedeſtal, without reſting againſt the Edges thereof.

When the Motion of the Speculum is ſomewhat abated, and the Ship's Motion begins to affect it (which will never be the Caſe in uſing the Floating Mirrour) the Vibration will by a gradual Increaſe, become an Angle too big for Eſtimation, therefore in waiting for a Meridian Altitude, if this ſhould happen before the Sun is at the higheſt, ſtop the Speculum; and having the Whirler ready, renew its Motion; which will generally continue fit for Obſervation 8 or 10 Minutes.

N. B. Always remember, before you whirl the Speculum, to put 2 or 3 Drops of Sweet Oil into the concave Pedeſtal, and when the Oil is foul'd by Uſe, it muſt be wip'd clean off, and ſome freſh put on.

In obſerving the Sun's Altitude in this Manner, with either of theſe Inſtruments, the riſing or falling of the Sun will be perceived in half the uſual Time.

Obſervations made below the *Nore*, on Board His Grace the Duke of BEDFORD's Yacht, *Sept.* 7, 1743. In Purſuance of an Order from the principal Officers and Commiſſioners of his MAJESTY's Royal Navy: For the Trial of Mr. SEARSON's Whirling Speculum, or Artificial Horizon.

TWenty-ſix Obſervations were taken, ſome under Sail, others at Anchor, both before and after Noon; and alſo when the Sun paſt the Meridian, as may be ſeen in the following Table; whereof the firſt Column is the true Time, by a good Watch rectified at the Beginning. The ſecond Column is the *Sun's true Altitude* at that Time. The third is the *Sun's apparent Altitude*, that is, allowing for the Refraction. The fourth is the Altitude by Obſervation. The fifth and laſt is the Difference between the apparent and obſerved Altitudes, which ſhews the Error of the Obſervation.

There was a great Swell, and the Obſervations were made upon the Poop of the Yacht, which ſuffered the greateſt Motion. — And it appears upon the Whole, that not more than ſix of the Obſervations differed above five Minutes from the Truth, and upwards of half differ no more than 2 or 3 Minutes.

Hence it is evident, that this artificial Horizon is capable of obtaining the Latitude in almoſt all Weathers, within 3 or 4 Minutes, by the Sun or Stars, without the Help of the natural Horizon.

We may likewiſe diſcover by this, and the viſible or natural Horizon at the ſame Time, how much the Horizon is refracted at different Seaſons, and in different Latitudes; a Thing of no ſmall Importance in Navigation.

At the *Nore*, the 12*th* of *Sept.* 1743. The floating Light bearing Weſt 15° North, diſtance about two Miles, where the Sun's Meridian Altitude, was found to be 38° 32′, from which deducting 1 Min. for the Refraction, there remains 38° 31′ which as the Sun entered *Libra* that Day at Noon, is the Complement of the Latitude 51° 29′. —— Which differs a Min. from that taken by Mr. *Bradley*, in the Year 1732. *Vide Philo. Tranſ.* N° 425.

Altitude

Altitude.										
Time			True		Appar.		Obſerv.		Error	
By Mr. *SEARSON.*										
H.	M.	S.	°	′	°	′	°	′	°	′
8	16	22	20	30	20	32	20	23	00	09
	27	38	21	59	22	01	22	00	00	01
	39	05	23	33	23	35	23	35	00	00
9	03	14	26	34	26	36	26	46	00	10
	08	53	27	15	27	17	27	20	00	03
10	42	39	36	02	36	03	36	07	00	04
	48	38	36	24	36	25	36	18	00	07
12	00	00	38	32	38	33	38	32	00	01
4	19	12	15	19	15	22	15	21	00	01
	21	24	15	00	15	03	14	59	00	04
	30	27	13	41	13	44	13	39	00	05
	33	06	13	17	13	20	13	08	00	12
	38	22	12	28	12	32	12	33	00	01
By Capt. *Chriſtopher Middleton.*										
12	00	00	38	32	38	33	38	32	00	01
3	11	22	24	40	24	41	24	39	00	02
	20	17	23	31	23	33	23	28	00	05
	27	47	22	31	22	33	22	36	00	03
	35	32	21	29	21	31	21	19	00	12
By Mr. *William Grimmett.*										
12	00	00	38	32	38	33	38	32	00	01
3	07	58	25	05	25	07	25	11	00	04
	43	34	20	23	20	24	20	13	00	11
	53	06	19	03	19	05	19	00	00	05
	57	46	18	24	18	27	18	30	00	03
By Mr. *John Ruſſel.*										
3	15	50	24	07	24	09	24	11	00	02
	24	02	23	02	23	04	23	00	00	04
	55	26	18	44	18	47	18	48	00	01

THE DESCRIPTION OF THE Floating Mirrour,

Invented by

Capt. *HENRY ELLIS*.

LET a Wooden, China or Glaſs Bowl be filled with Quickſilver, and ſlide a glaſs Plane upon the Surface thereof, ſo as to exclude the Air from between the Surface of the Mercury and Glaſs; the Mercury would perform this Office alone, could its Surface be kept from trembling, which Difficulty is elegantly removed by this Glaſs floating thereon. It is to be held in the Hand as the Whirling Speculum is; and when thus prepared, is ready for Obſervation.

The Manner of making an Obſervation with Mr. Hadley's Quadrant, *and either the* Whirling Speculum, *or* Floating Mirrour.

As there is no Difference in the Application of the Quadrant, to either of theſe artificial Horizons, one Direction will ſerve for both, which take as follows.

The Application of the Quadrant, is as eaſy to either of theſe Inſtruments, as to the Horizon itſelf, and differs only in this; inſtead of looking at the Sea, look through the Sight Vane, and tranſparent Horizon Glaſs, at the reflected Image of the Sun in the Speculum, or floating Mirrour, and move the Index till the reflected Image of the Sun from the Index Glaſs, coincides with, or covers that ſeen in the Speculum; and obſerve, if the Image ſeen in the Speculum, have any Tremor, or Vibratory Motion; the ſtill Image of the Index Glaſs muſt be reflected into the Middle of that Vibration, the Degrees and Minutes then ſhewn by the Index, is the Sun's double Altitude; for Inſtance,

Suppoſe 85° 40′, the Half as, *viz.* 42° 50′ is the Sun's true Altitude.

Obſerve this as a general Rule, whenever the fore Obſervation, or South Vane of the Quadrant is uſed, which muſt be for all Altitudes not exceeding 45 Deg.

All the other Altitudes are to be taken with the back Obſervation, or North Vane of the Quadrant.

Holding therefore the North Vane of the Quadrant to your Eye, look thro' the Slit of the Horizon Glaſs, at the reflected Image of the Sun, ſeen in the Speculum, and keeping ſight of it, incline the Head of the Quadrant towards the Speculum, till the Vane you are looking through reflects the Index Glaſs between your Eye, and the Speculum, then by moving the Index, make the two Images coincide as above. The Degrees and Minutes denoted by the Index, is the double Complement of Altitude; for Example, ſuppoſe 38° 40′ the Half, as follows 19° 20′, is the Complement of the Sun's Altitude.

Take particular Notice, That when the South Vane of the Quadrant is uſed, the Index gives the double Altitude, and when the North Vane, the double Complement of Altitude. It don't ſignify what Part of the Speculum the Sun's Image is received from, neither is the different Diſtances of the Obſerver to be at all conſidered, the reflected Angle being the ſame at all Diſtances; ſo that when the Ship has a great Motion by holding the Quadrant near the Speculum, there will be ſo large a Field, that the Obſervation may be taken with Eaſe.

A Caution to be obſerved in taking the Altitudes of Stars, by theſe Artificial Horizons.

It is beſt not to bring the two Reflections of a Star in to contact, for being but Points, the Section of the Glaſs would immediately cover them; but to lay that given by the Index on the Right Hand Side of that ſeen in the Speculum, at a ſmall Diſtance from it, obſerving, as before, if the Image in the Speculum vibrate, the Mean of that Vibration is to be taken, and the Index gives either the double Altitude, or the double Complement of Altitude, as before ſhewn.

In taking high Altitudes, the Tranſit of the Stars will be almoſt inſtantly determined; hence we have a Method for finding the Latitude of the Ship, and Time of the Night at one Obſervation, with all requiſite Exactneſs, not exceeding 40 Deg. *viz.* by taking Altitudes near the Zenith, for their Tranſits will be determined in two or three Minutes at moſt, by a correct Sea Horizon, and by our preſent Method of taking a double Angle in half that Time; and as there are many Stars that come upon the Meridian, between 70 Deg. of Altitude, and the Zenith, by having thei right Aſcenſions, and a good Watch, the Departure may very often be had with greater Exactneſs, by the Difference of Time, than any other Method; eſpecially, when by the Sea running high, the Log is render'd impracticable or precarious, which will, in a great Meaſure, leſſen the Errors too often occaſioned, by having no Obſervation for many Days together; and when by various Traverſes, the dead Reckonings are render'd precarious, by comparing the computed Latitude with the obſerved, as often as may be, the Errors will be infinitely leſſened, the Stars affording ſo many Opportunities.

FINIS.